Status of the Gila Topminnow

(Poeciliopsis occidentalis occidentalis)

in the United States

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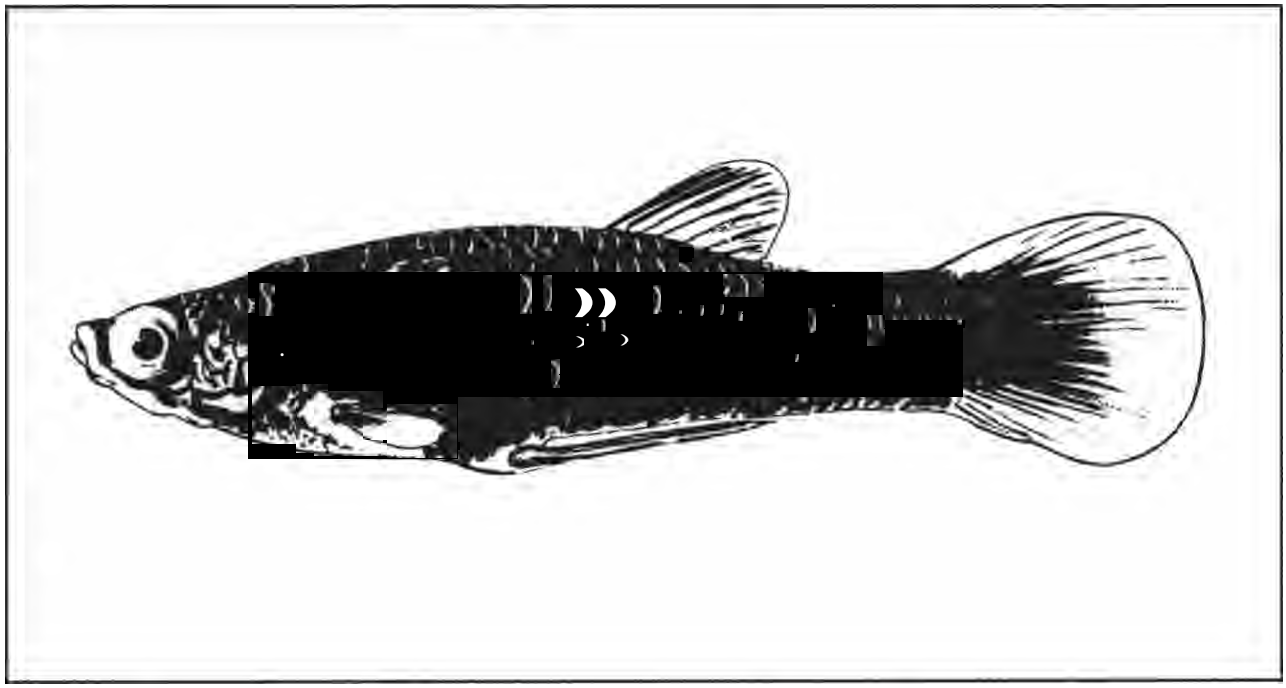

A Special Report on Project **E-1**
Title VI of The Endangered Species Act of 1973, As Amended

Project Leader: Terry B. Johnson

Arizona Game and Fish Department
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INTRODUCTION

The Sonoran topminnow (Poeciliopsis occidentalis) was once widespread and abundant in southern Arizona (Hubbs and Miller 1941), but was listed as endangered in 1967 (U.S. Dept. Interior 1986). Two reasons are generally given for the topminnow's decline (Minckley and Deacon 1968, Schoenherr 1974, Minckley et al. 1977, Meffe et al. 1983): 1) habitat modification and loss, and 2) predation from exotic fishes, especially mosquitofish (Gambusia affinis). In the United States, the Sonoran topminnow includes two subspecies (Minckley 1973): the Yaqui topminnow (P. o. sonoriensis) native to the Yaqui River drainage, and the Gila topminnow (P. o. occidentalis) native to the southern part of the Colorado River drainage. Although both subspecies also occur in Mexico (Meffe et al. 1983), Mexican populations are not considered here. This report summarizes the status of Gila topminnow in the United States in 1987 -- six years after intensive recovery actions began. Biological, social, and political consequences of downlisting this subspecies to threatened status are also discussed in view of 1987 results.

Background

In September 1981, a memorandum of understanding (MOU) between the U.S. Fish and Wildlife Service, U.S. Forest Service, and Arizona Game and Fish Department established guidelines for the introduction of Gila topminnow into habitats identified and administered by the U.S. Forest Service. This MOU also set criteria for monitoring introductions and initiating downlisting and delisting procedures. In 1982, an intensive topminnow introduction effort began, and in 1983 a Recovery Plan was finalized which incorporated most of the MOU's guidelines. The Recovery Plan treated subspecies separately, and for the Gila topminnow these criteria were as follows (USFWS 1983):

Downlist when:

A. Twenty populations have been successfully reestablished in the wild, within historic range, and have survived for at least 3 years.

Before 1987 -- Delist when:

A. At least 50 percent of the existing natural, reclaimed, or newly discovered natural populations have been secured through removal of and protection against invasion of mosquitofish and other predatory species, and through protection of the habitat by management plans, cooperative agreements, land acquisition, or other means.

(and)

B. Fifty populations have been successfully reestablished in the wild, within historic range, and have survived for at least 3 years, or thirty populations have been successfully reestablished and have survived for at least 5 years.

After 1987 -- Delist when:

A. Fifty populations have been successfully reestablished in the wild, within historic range, and have survived for at least 3 years, or thirty populations have been successfully reestablished and have survived for at least 5 years.

The Arizona Game and Fish Department monitored introduced topminnow populations in 1983 and 1985 (Brooks 1985, 1986). In 1985, 30 introduced populations had survived 3 or more years, exceeding the Recovery Plan's criteria for **downlisting** the subspecies from endangered to threatened status (Brooks 1986). Three topminnow populations introduced outside historic range (Minckley 1973, USFWS 1983), are omitted from the balance of this report (Appendix C -- sites #28, 36, 44). Although Brooks (1986) incorrectly counted these populations as contributing toward recovery, deletion of these sites would not have changed his general conclusions. In October 1987, as this report was being written, a proposal to downlist the Gila subspecies to threatened status was being prepared by the Office of Endangered Species, U.S. Fish and Wildlife Service, Albuquerque, New Mexico (J. Johnson, pers. comm.).

Definitions and Conventions

The explicit meaning of terms and phrases used in the Recovery Plan and subsequent reports (USFWS 1983; Brooks 1985, 1986) is pivotal to the management of Gila topminnow. The meaning of "successfully reestablished", for example, is not defined, but seems to imply some level of assurance that populations involved are healthy and likely to persist. Likewise, the intent of "in the wild" is not clear. Are cement watering troughs, springboxes, and windmill-fed tanks considered "in the wild"? Even the meaning of population needs clarification, since several discrete locales downstream from introduction sites now support topminnows via flood transport or dispersal. Should these be considered separate populations or extensions of existing populations?

In this report, introductions (or reintroductions) are stockings of topminnow into free-living situations, such as creeks, springs, stockponds, rivers, or watering troughs. These do not include populations in aquaria such as at various museums and universities, or at temporary rearing facilities such as

Dexter National Fish Hatchery. After Brooks (1985, 1986), successful introductions are those supporting any topminnow, regardless of population or habitat condition.

Natural populations are those which existed prior to fish transplantations by man, and which exist today in their historic locations free of known anthropogenic mixing with other populations. Thus, following renovations, Bylas Spring remains natural since it was restocked with fish native to Bylas Spring, but Salt Creek is not natural since it was restocked with fish native to Middle Spring (Brooks 1986). Although many populations of Yaqui topminnow have become mixed unnaturally (Minckley and Brooks 1985; footnote 13), this has not been documented for Gila topminnow.

In this report, each discrete body of water supporting natural populations of Gila topminnow is considered separately. However, these populations are grouped geographically into four areas. Populations within each area probably share similar biogeographical and possibly genetic histories. Some areas surely experienced considerable intra-populational gene flow in recent history. These areas and their component populations are: Bylas (Bylas Spring -- site #7, Middle Spring -- #6); San Rafael Valley (Sheehy Spring -- #3, Sharp Spring -- #4, Santa Cruz River -- #10); Sonoita Creek (Cottonwood Spring -- #1, Monkey Spring -- #2, Sonoita Creek -- #9, Redrock Canyon -- #11); and Cienega Creek (Cienega Creek -- #5).

METHODS

Introduced Populations

Introduced populations were monitored in 1986 and 1987 in July and August when water levels tended to be low but topminnow densities high (USFWS 1983). Sites deemed unsuccessful were generally rechecked once the following year. Because topminnow populations varied greatly in population and habitat quality, they were classified in 1987 into one of four categories:

Category 1 populations are those with moderate to high numbers of individuals in habitats with natural surface water expected to persist indefinitely without anthropogenic support;

Category 2 populations are those with moderate to high numbers of individuals in habitats expected to persist indefinitely only with anthropogenic support;

Category 3 populations are those with such low numbers, or with habitat of such limited quantity or quality, that populations are not expected to persist many years; and

Category 4 populations are those threatened by mosquitofish, regardless of population size or habitat quality.

Although populations were categorized subjectively, this seems preferable to simply stating the number of successful introductions regardless of condition. Classifications were based on my experience monitoring topminnow populations over two summers. More objective methods of assessing persistence of populations have not been effective (Brooks 1985), and will probably not be refined before the downlisting proposal is formally considered (J. Brooks, pers. comm.). Each population and associated habitat, including my classification rationale, is described in Appendix C.

Populations established by dispersal from introduction sites may or may not count toward recovery goals -- this contingency was not addressed by the Recovery Plan. Provisionally, I have omitted these sites from totals contributing to Recovery Plan goals since their legal and management status are unclear. I have, nonetheless, described and catagorized each site in Appendix C.

During 1986 and 1987, introduced populations were monitored with dipnets (1/8 inch mesh X 1.5 foot^4 opening) throughout each site's watered section. Voucher samples were taken from sites with sufficient numbers of fish to allow such collection. All collections are deposited in the Collection of Fishes, Department of Zoology, Arizona State University. Sites with both mosquitofish and topminnow were sampled to obtain ratios of numbers of the two species. Comparison of such ratios over time allows tracking of the populations as they interact, providing insight about the co-occurrence or extirpation of topminnows in such situations (Minckley et al. 1977, Meffe et al. 1982). Potential topminnow habitats near and especially downstream from introduction sites were also checked. Finally, I investigated several introductions made before 1980 but of unknown status in 1986 (Minckley and Brooks 1985), and several reports of other "fishes" in isolated waters.

Natural Populations

Natural topminnow populations were monitored in 1986 and 1987 using the methods described for introduced populations. Populations threatened by mosquitofish were sampled to obtain ratios of the two species for analysis as described above. In 1987, ratio counts were obtained in seven different pools at Sharp Spring to determine if mosquitofish remained distributed non-randomly in this system as reported previously by Meffe et al. (1982).

Following reports of mosquitofish (Brooks 1986, Sheila Dean pers. comm.), Redrock Canyon was surveyed to determine the distribution and abundance of fish in the main and side-drainages. Nearly all stocktanks and watered sections in the drainage, as well as portions of adjacent Harshaw Creek drainage, were visited. Surveys of Sonoita and Cienega creeks also attempted to document the distribution and abundance of topminnow and exotic species in these systems.

RESULTS

Introduced Populations

Many introductions of Gila topminnow have been attempted within historic range in Arizona (Minckley and Brooks 1985, Brooks 1985, 1986; this report -- Table 1). Before 1982, 92 documented introductions were made by diverse agencies and individuals. An unknown number of undocumented introductions are also suspected from that period. In 1982, 64 sites on national forest land and 2 sites on private land were stocked. In 1983, 23 additional sites on national forest land were stocked. In 1985, five sites on Bureau of Land Management land and two sites on national forest land were stocked. In 1986, a single site on the San Carlos Apache Indian Reservation was stocked. In 1987, no introductions were made, but future introductions on Bureau of Land Management land are anticipated. Two additional introductions in 1982 on Fort Huachuca Military Reservation were documented in 1986 (Dennis Coleman pers. comm.). Hence, 99 documented stockings of Gila topminnow have occurred within historic range since 1982 (Appendix A).

Thirty-five introduced populations of Gila topminnow existed within historic range in Fall 1987 (Table 1). Thirty of these populations persisted at least 3 years (since 1984 or earlier), and 23 persisted at least 5 years (since 1982 or earlier). Although most efforts to introduce Gila topminnow before 1982 were unsuccessful (Minckley 1969), six of these populations existed before official recovery efforts began in 1982 (USFWS 1983, Brooks 1986). Overall, 18% of the 191 known introductions attempted, and 28% of the 99 introductions attempted since 1982 persist in 1987 (Appendix A, B). The oldest known introduced population was stocked in 1976 at Hidden Water Spring -- site #48 (Minckley and Brooks 1985). Five extirpations between 1985 and 1986, and 10 between 1986 and 1987 were documented (Table 2).

Six additional populations of Gila topminnow exist in 1987, 5 due to dispersal from introduction sites and one from an unknown source (Table 3). One of these populations is Category 2, 4 are Category 3, and 1 is Category 4. These "dispersal" populations are spatially distinct from their probable sources, except

Table 1. Summary of all known introductions of Gila topminnow (Poeciliopsis o. occidentalis) within historic range through 1987.

INTRODUCTIONS[1]		NUMBER OF INTRODUCTIONS SUCCESSFUL[2] IN:				
Year	# sites	1983	1984	1985	1986	1987
Prior to 1982	92	6		6	6	6
1982	68	36		28	24	17
1983	23			10	9	7
1984	0			0	0	0
1985	7				5	4
1986	1					1
Totals	191	42		44	44	35
After 1981	99	36		38	38	29

[1]See Appendix A.
[2]See Appendix B

Table 2. Summary of introduced Gila topminnow (*Poeciliopsis o. occidentalis*) populations that failed between 1985 and 1987, with probable reasons for extirpation.

SITE NAME	LAST YEAR VIABLE	PROBABLE REASON FOR Extirpation
Chalky Butte Well Tank	85	dried
Frog Spring	85	low water
Sheep Spring	85	low water
Johnson's Wash Spring	85	unknown
Two-mile Spring	85	dried
Unnamed Spring #1	86	dried
Unnamed Spring #2	86	dried
Hull Spring	86	unknown
T.T. Spring	86	low water, dried ?
Unnamed (T.T.) Spring	86	dried
Unnamed Spring Tank #498	86	low oxygen ?
Unnamed Spring Fed Tank #408	86	dried
Tule Creek Seep (2E)	86	low water, dried ?
Unnamed Creek #3	86	dried
Howard Well	86	low water, dried ?

Table 3. Summary of Gila topminnow (Poeciliopsis o. occidentalis) populations in 1987 derived from emigrants of introduced populations or from unknown sources. Condition categories are defined in the text. *See* Appendix C for descriptions of each site and classification rationale.

SITE NUMBER	NAME AND LOCATION OF NEW POPULATION	CONDITION	PROBABLE SOURCE
95	Humbug Creek (T7N, R1E, S7/8/17)	4	Cow Creek (T8N, R1W, S25)
68b	Unnamed Drainage #68 (T2N, R9E, S1)	2	Mesquite Tank (T2N, R9E, S1)
67b	Castle Creek (T1ON, R2E, S31 SW)	3	Bench Well (T1ON, R1E, S23)
31	Pasture Well (T15N, R3E, S16)	3	Unnamed Spring #2 (T15N, R3E, S16)
102	Red Creek (T9IN, R5E, S24)	3	Thicket Spring (T1ON, R5E, S35)
103	Rincon (T14N, R16E, S14/15)	3	Unknown

perhaps during flood events. One population (#67b) dispersed about 5 km downstream from its probable source. Three of the probable source populations are now extinct. The sixth population is probably an undocumented introduction since the reach of stream inhabited also supports goldfish (Carassius auratus) and apparently dries occasionally (W. Hayes, W. Minckley, and B. Bibles, pers. comm.). These six populations are not counted in meeting Recovery Plan goals (see Methods).

Ten of the 35 successful topminnow introductions in 1987 are classified as Category 1, 17 are Category 2, 6 are Category 3, and 2 are Category 4 (Appendix B, C). Hence, 27 populations (Categories 1 and 2) exist free of mosquitofish and other immediate threats. Ten populations (Category 1) exist in natural aquatic situations which should persist indefinitely without anthropogenic support. Eight populations (Categories 3 and 4) are threatened for various reasons (Appendix C), and should not be considered viable, long term populations. Threats include mosquitofish (e.g. 97% of Poeciliids at site #16), non-reproduction (e.g. none apparent in 1986 and 1987 at site #25), very small populations (estimated at less than 10 individuals at sites #18 and #25), and very limited habitats (e.g. a single cement watering trough at site #38, a single 0.5 m^2 pool at site #74). Excluding populations in Categories 3 and 4, 22 populations have persisted at least 3 years (since 1984 or earlier), and 17 have persisted at least 5 years (since 1982 or earlier). These populations continue to exceed requirements for downlisting the Gila subspecies from endangered to threatened status (USFWS 1983, Brooks 1986, see criteria in introduction).

Natural Populations

Ten natural populations of Gila topminnow persist in 1987 (Table 4). Four of these remain free of exotic fishes while six are threatened to varying degrees by mosquitofish (Appendix C). An eleventh natural population in Salt Creek was lost between 1980 and 1984 following invasion by mosquitofish (one red shiner [Notropis lutrensis] was also observed; Brooks 1986; W. Minckley, pers. comm.). Renovations of natural topminnow populations (Meffe 1983) have not been attempted since 1984 (Brooks 1986), and conservation easements or other forms of formal protection have not been secured for any of the seven natural populations on private property.

Topminnow at Sheehy (site #3) and Sharp Springs (#4) were nearly extinct in 1987 (Table 4, Appendix C), although they have coexisted with mosquitofish in these sites since at least 1979 (Meffe et al. 1983). Mosquitofish also dominated Bylas Spring (site #7) in June 1987 about 1.5 years after reinvasion (Table 4, Appendix C). Relatively high proportions of topminnow persist in Sonoita Creek below Patagonia Lake despite the presence of

Table 4. Summary of natural populations of Gila topminnow (*Poeciliopsis o. occidentalis*) in 1987. Mosquitofish (*Gambusia affinis*) dominance (# mosquitofish/ [# mosquitofish + # topminnow] X 100) is given for data in 1987. N is the number of Poeciliid fishes counted to estimate dominance.

SITE NUMBER	POPULATION	LOCATION	N	MOSQUITOFISH DOMINANCE
1	Cottonwood Spring	T2OS R16E S33	--	none
2	Monkey Spring	T21S R16E S03		none
3	Sheehy Spring	San Rafael Valley	>200	> 99%
4	Sharp Spring	San Rafael Valley	607	92%
5	Cienega Creek	T18S R17E S34/35		none
6	Middle Spring	San Carlos I. Res.		none
7	Bylas Spring	San Carlos I. Res.	128	99%
9	Sonoita Creek	T22S R14E S25/34	289	variable
10	Santa Cruz River	T24S R17E S11	56	81%
11	Redrock Canyon	T22S R17E S07/12	185	variable

mosquitofish since at least 1977 (Minckley et al. 1977). Relative abundance of topminnow in Sonoita Creek seems most stable about 1.6 to 2.0 kilometers below Patagonia Lake with higher percentages of mosquitofish above and below this area (Brooks 1986, this study -- Appendix C). The Sonoita Creek drainage below Patagonia Lake may have topminnow refugia in other than the mainstream (Minckley et al. 1977, Meffe 1984), and will be searched thoroughly during 1988 monitoring efforts.

Mosquitofish invaded Redrock Canyon from at least 2 stocktanks located in the drainage's headwaters. In 1987, mosquitofish occurred downstream from Cott Tank (T22S, R17E, S27 NW1/8) and Down-under Tank (T22S R17E S15 E1/8) to at least the vicinity of gate springs (T22S, R17E, S7 center). Mosquitofish were abundant and topminnow absent in reaches immediately below each tank. Topminnow occurred from about 1 km below Cott Tank downstream to below Redrock Ranch (T22S R16E S2 S1/8). Thus, mosquitofish and topminnow co-occurred over a broad (5 km) zone in 1987, with mosquitofish exclusively above, and topminnow exclusively below this zone. Largemouth bass (Micropterus salmoides) and sunfish (Lepomis sp.) occurred in larger pools in the same areas as mosquitofish. Although a third unnamed tank (T22S R17E S21 center) contained mosquitofish and bluegill (Lepomis macrochirus), no fish and very little water occurred for 4 km below this tank.

Topminnow were found in four isolated and previously unreported sites within Redrock Canyon drainage: in single pools near the mouths of 2 unnamed drainages feeding south into Oak Grove Spring drainage (T21S R16E S35 E border and T22S R16E S2 NW1/8), in a developed spring pool near the confluence of Oak Grove Spring drainage with Redrock Canyon (T22S R16E S2 NWI), and in lower Lampshire Canyon (T22S R17E S6 Si). All of these sites had topminnow and longfin dace (Agosia chrysogaster), but no mosquitofish, in April or May 1987. The first three sites supported only longfin dace on 25 July 1987, while Lampshire Canyon was not revisited in July. A single Gila mountain sucker (Pantosteus clarki) was collected from Redrock Canyon below Redrock Ranch (T22S R16E S2 S1/8).

A recent report of mosquitofish in lower Lampshire Canyon (Brooks 1986) was not confirmed in May 1987; furthermore, no source of mosquitofish, including stocktanks or springs, could be found in Lampshire Canyon drainage. Likewise, the isolated and fleeting occurrence of topminnows in parts of Redrock Canyon is puzzling. Possibly topminnow disperse upstream during periods of high water and later become isolated when water recedes.

DISCUSSION

Gila topminnow now occur in many more localities over a much wider distribution than when intensive recovery action began. If the subspecies were being listed now, it might qualify only for threatened status. Downlisting criteria stipulated in the Recovery Plan (USFWS 1983) were met in 1985 (Brooks 1986), and continue to be met in 1987. Accordingly, downlisting of Gila topminnow from endangered to threatened status is being proposed in 1987 (Brooks 1986; J. Johnson, pers. comm.). In considering this proposal both biological and socio-political consequences must be considered.

Biological Consequences of Downlisting

The long term viability of many "successful" topminnow introductions is tenuous. Even without considering Categories 3 and 4, most populations on which downlisting is proposed do not exist in natural aquatic habitats. Seventeen (Category 2) of 27 populations (Categories 1 and 2) exist in habitats which depend on pumped groundwater, impounded water, or some other anthropogenic support. These habitats will likely not persist without perpetual human maintenance. Even in natural aquatic systems persistence is not assured. Glen Jennings (pers. comm.), a longtime rancher in the Bloody Basin area, is certain at least four habitats where topminnow are now "succeeding" (sites #15, 16, 46, and 102) were dry in 1977, and will dry again when a sufficiently strong drought occurs. A mild drought in 1987 apparently had serious repercussions on introduced topminnow populations (Table 2). One wonders how remaining populations will fare when a strong drought occurs. Flooding is another event which threatens even older, seemingly well-established populations (Collins et al. 1981, Brooks 1985).

The challenge of endangered species management is the conservation of diversity under constraints of rarity. As much as "species" themselves, diversity within a species (or subspecies) should be maintained for its uniqueness, and to insure adaptability over the long term (Frankel 1983). All but two introductions of Gila topminnow since 1981 (and most introductions prior to 1981) represent a single genetic lineage (Monkey Spring -- site #2; Brooks 1986). Ironically, Monkey Spring topminnow are among the least fecund of several populations studied (Constanz 1979, Schoenherr 1977), and were recently reported to be relatively unvaried genetically (Vrijenhoek et al. 1985). Although empirical evidence from fish populations is scarce, more heterogenous genetic lineages would presumably be more adaptable, thus more likely to persist following introduction to novel environments (Meffe 1986).

The Monkey Spring topminnow lineage is now well protected, but other natural lineages are not. Six of 10 extant natural populations are threatened by mosquitofish and low population size; several are near extinction. Moreover, six natural populations exist on private land dedicated primarily to uses other than conservation. These populations currently have no formal protection. The precarious nature of the topminnow's existence is underscored by recent and impending loss of natural topminnow populations: a springhead outflow near Mammoth, Arizona (McNatt 1979); Cocio Wash (USFWS 1983); Salt Creek (Brooks 1985); potentially Sharp, Sheehy, and Bylas Springs (this study). Although Gila topminnow are less threatened now than in the past, the subspecies' total genetic diversity must be at its lowest point ever. Thus, topminnow recovery through 1987 has not conserved genetic diversity -- an essential component of any species' well being (Frankel 1983).

Future introductions of topminnow should derive from other than Monkey Spring stock (Vrijenhoek et al. 1985). Fish from a more heterogenous population (Sharp Spring, site #4; see Vrijenhoek et al. 1985) are now in culture at Dexter National Fish Hatchery as broodstock (Brooks 1986). Other natural populations should also be stocked into habitats free of mosquitofish. At least one population from each geographic area (Bylas, San Rafael Valley, Sonoita Creek drainage, Cienega Creek) should be introduced to new sites within their respective geographic areas. Finally, attention to the relative success of topminnow populations from sources with different levels of heterozygosity should prove useful in assessing the importance of heterozygosity to this and future reintroduction efforts (Meffe 1986).

Under the current Recovery Plan delisting will occur (after 1987) when 50 populations have been successfully reestablished in the wild, within historic range, for at least 3 years, or 30 populations have been so established for at least 5 years. At present, only 27 introduced populations within historic range are judged likely to persist for long periods of time (i.e. Categories 1 and 2). Clearly, continued monitoring of existing populations of Gila topminnow, and additional introductions from several natural sources, are required before the subspecies can be considered biologically secure. Hopefully, self-sustaining natural systems free of mosquitofish can be found for at least some of these introductions. Without them complete recovery is unlikely.

Socio-political Consequences of **Downlisting**

Recovery efforts for Gila topminnow have been intensive since 1982 (USFWS 1983, Brooks 1985, 1986, this report). As biologists, most of us appreciate the importance of biological consequences such as those discussed in the preceding section. It is also essential that we appreciate the importance of social and political support for endangered species programs. Without this support, the Endangered Species Act would not exist, or might not be reauthorized. If downlisting of Gila topminnow does occur, its "success" should be widely publicized to generate support for endangered desert fishes and the Endangered Species Program in general. **Downlisting** is an important and tangible product for politicians and the public to see.

Downlisting the Gila topminnow from endangered to threatened status would shift priorities. This may be appropriate given that several species in the southwestern United States are in substantially greater peril of extinction. Bonytail chub (*Gila elegans*) and woundfin (*Plagopterus argentissimus*) are two examples. Despite this shift, however, one pitfall must be avoided. We must not lose the progress we have gained with Gila topminnow. Such a loss would be tragic both socio-politically and biologically. Accordingly, it is essential that recovery of Gila topminnow continue. Future actions should include protection, monitoring, introductions, renovations, and control of mosquitofish for both natural and introduced populations. It is also imperative that remaining natural populations receive as much protection as possible; in the case of private lands, outright purchase or conservation easements must be accomplished.

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APPENDIX A. Names and locations, or references with names and locations, of all known introduction sites for Poeciliopsis o. occidentalis, as of October 1987.

NUMBER OF SITES	NAME AND LOCATION (OR REFERENCE)
	Introduced before 1982
90	(see Minckley and Brooks 1985)
1	Cow Creek (T8N, R1W, S25)
1	Heron Spring (San Rafael Valley)
	Introduced in 1982
64	(see Table 1 in Brooks 1985)
1	Tule Creek Spring 1E (T8N, R1W, S28)
1	Tule Creek Seep 2E (T8N, R1W, S28)
1	Buffalo Corral Pond Spring (Fort Huachuca Mil. Res.)
1	Kino Spring (Fort Huachuca Mil. Res.)
	Introduced in 1983
23	(see Table 2 in Brooks 1985)
	Introduced in 1984
3 (not in historic range)	Peoples Canyon (T12N, R10W, S14 south boundary) Tres Alamos (T1ON, R9W, S13 NW ¼) Yerba Mansa (T11N, R11W, S21 NW ¼)
	Introduced in 1985
1	Green Tank (T3S, R15E, S7)
1	Mescal Warm Spring (T3S, R17E, S20)
1	Big Spring (T6S, R25E, S5)
1	Cold Spring (T5S, R24E, S17)
1	Howard Well (T11S, R29E, S36)
1	Salt River at Horseshoe Bend (T3N, R15E, S2)
1	Cherry Creek at Ellison Ranch (T1ON, R15E, S5 center)
	Introduced in 1986
1	Salt Creek near Bylas (San Carlos Apache Indian Reservation)

191 total introductions known

99 introductions since 1982 (start of official recovery effort)

APPENDIX B. Summary of introduction sites supporting Gila topminnow (Poeciliopsis o. occidentalis) in 1987. Condition categories are defined in the text. See Appendix C for descriptions of each site including classification rationale.

SITE NUMBER	SITE NAME	LOCATION	CATEGORY
	Introduced before 1982		
48	Hidden Water Spring	TO3N RO9E S21	1
49	Seven Springs	TO7N RO5E S09	1
72	Cow Creek	TO8N RO1W S25	2
75	Tule Creek	TO8N ROlE S28/29	1
76	Heron Spring	San Rafael Valley	1
80	main pond	Boyce-Thompson Arboretum	2
	Introduced in 1982		
18	Mud Spring	TO5N R08E S03	3
20	Walnut Spring	TO6N R08E S03	2
21	Sycamore Spring	TO3N R15E S24	2
23	Yellowstone Tank	T132 R17E S20	2
24	Indian Spring	TO3N R1OE S24	1
33	Government Spring	T13N RO3E S33	2
38	Mesquite Flat Trough	TO6N R1OE S34	3
40	Artesian Well #3	TO6N R11E S08	2
41	Corner Artesian	TO6N R11E S20	2
42	Kayler Spring	TO7N R1OE S23	4
43	Reed Spring	TO8N R1OE S34	2
45	Mesquite Spring Tank	TO5N R08E S31	3
46	Horse Creek	T08N SO6E S01	2
74	Tule Creek Unn. Spring 1E	TO8N ROlE S28	3
77	Cottonwood Artesian	TO5N R13E S34	2
98	Kino Spring	Fort Huachuca	2
99	Buffalo Corral Pond Spring	Fort Huachuca	3
	Introduced in 1983		
12	Lower Mine Spring	T13N RO5E S29	2
15	Thicket Spring	T1ON R05E S20	2
16	Mud Spring Tank	T9iN R5E S20	4
19	Dutchman's Grave Spring	TO9N RO7E S16/21	1
25	Campbell Flat Spring	T1ON RO2W S30	3
26	Bain Spring	T1ON RO2W SO6	1
32	Upper Horrell Spring	TO2N R12E S11/12	1

APPENDIX B (continued). Summary of introduction sites supporting Gila topminnow (Poeciliopsis o. occidentalis) in the United States in 1987. Condition categories are defined in the text. See Appendix C for descriptions of each site including classification rationale.

SITE NUMBER	SITE NAME	LOCATION	CATEGORY
		Introduced in 1984	
28	(not in historic range)	Peoples Canyon (T12N, R10W, S14 south 1/8)	
36		Tres Alamos (T10N, R9W, S13 NW ¼)	
44		Yerba Mansa (T11N, R11W, S21 NW 1)	
		Introduced in 1985	
81	Green Tanks	TO3S R15E S07	1
82	Mescal Warm Springs	TO3S R17E S20	1
83	Big Spring	TO6S R25E S05	2
84	Cold Spring	TO5S R24E S17	2
		Introduced in 1986	
8	Salt Creek (near Bylas)	San Carlos Apache I. Reservation	2
		No introductions in 1987	

APPENDIX C. An annotated list of all known populations of Gila topminnow (Poeciliopsis o. occidentalis) in the United States in 1987 arranged by site number. Ownership is in parentheses after each site's name and locations are given in Table 3, Appendix B, or are intentionally omitted. Measurements are approximate.

Natural Populations

1. Cottonwood Spring (private) arises on a hill above a normally dry section of Sonoita Creek and runs oblique to it before flowing through a grate above the creek into a man-made underground channel. The spring is 1-3 meters wide, 5-20 cm deep, and runs swiftly so that, even during floods, exotic fishes will not likely invade (Minckley et al. 1977). A small population of longfin dace also exists here.

2. Monkey Spring (private) arises at the top of an ancient limestone basin and runs 30 m before exiting into a cement flume which carries the water to a man-made lake. The flume's current and length make it a barrier to upward moving fish, including exotics (Schoenherr 1974). Literally hundreds of introductions of this population have been made throughout southern Arizona.

3. Sheehy Spring (private) is a cienega with a single large deep pool. Topminnow and mosquitofish have coexisted here since at least 1979, though topminnow are now very near extinction. The following chronology is compiled from several sources (Minckley et al. 1977, Meffe et al. 1983, Brooks 1986, this study):

Period	% mosquitofish in upper section of Sheehy Springs
1977	None
1979	42
1980	94
1985	>99
1986	88
1987	>99

4. Sharp Spring (private) is a series of deep pools connected by areas with shallow or subterranean flow through dense cienega vegetation. Natural floods appear to displace mosquitofish more than topminnows from this site, presumably because topminnows are better adapted to flooding than are mosquitofish. The result is coexistence of the two species over a longer period than in non-flooded areas (Meffe 1984). One introduction (Heron Spring -- site #76) was made with this population (Brooks 1986). Brood stock from this population is now at Dexter National Fish Hatchery awaiting further introductions. The following chronologies are compiled from several sources (Meffe et al. 1982, Meffe et al. 1983, Brooks 1986, this study):

4. Sharp Spring (continued)

Chronology of mosquitofish dominance (% mosquitofish)		Pattern of mosquitofish dominance (% mosquitofish) in:		
Period	Upper Sharp Spring	Pool # (Meffe et al. 1982)	September 1980	August 1987
August 1979	none	6	none	94
June 1980	none	7	"a few"	70
September 1980	some	10	none	85
December 1980	none	13	-50	97
August 1985	-50	16	-50	100
September 1985	none	17	-50	100
July 1986	52	18	-50	100
July 1987	94			

5. Cienega Creek (private) includes both mature cienega, deeply incised arroyos, and stream habitat. Topminnow are abundant from about the Empire Ranch (T18S R17E S26) downstream 8 km to below "The Narrows" on Empirita Ranch. In 1987, only longfin dace were observed in Cienega Creek north of Interstate 10. An extensive development project along Interstate 10 east of Cienega Creek could threaten the topminnow population through groundwater depletion, pollution, and increased human use, including introduction of exotic fishes into Cienega Creek.

6. Middle Spring (San Carlos Apache Indian Reservation) is a small spring presently isolated from the Gila River, hence invasion by mosquitofish. Fish from this site were stocked into Salt Creek (site #8) in 1986. Typha is dense at this site and succession might reduce or eliminate topminnow habitat.

7. Bylas Spring (San Carlos Apache Indian Reservation) is a small spring infested with mosquitofish (Brooks 1986). Two attempted renovations of this site were unsuccessful (Meffe 1983, Brooks 1986) and topminnow have been nearly extirpated. The following chronology is based on Brooks (1986) and this study:

Date	Status
1978	none
1979/80	first invade
- - - - - - attempted renovation - - - - -	
1983/84	barriers built
- - 1984 - -attempted renovation - - - - -	
December 1985	24% mosquitofish
September 1986	69% "
July 1987	98% "

8. Salt Creek (San Carlos Apache Indian Reservation) is no longer a natural population. See below.

9. Sonoita Creek (private) is primarily stream habitat with topminnows present but very uncommon in the vicinity of Patagonia (1 specimen found each year: 1986 and 1987). Topminnow were also found in isolated pools in Sonoita Creek adjacent to Cottonwood Spring (site #1). Topminnow were found in this study in several pools in Sonoita Creek below Patagonia Dam as reported by others (Minckley et al. 1977, USFWS 1983, Brooks 1986).

Date	Status
early records	topminnow abundant
1969	mosquitofish invade
1972-1975	only mosquitofish recorded
1977	around dam = mostly mosquitofish, in channel < 50% mosquitofish
1978-81	no topminnow reported, mosquitofish abundant
1982	topminnow reported present (in recovery plan)
1985	100% topminnow reported 1 mile below dam
1986	100% mosquitofish directly below dam
1987	Poeciliid ratio counts made at different distances below dam yielded:

Location (1987)	Status
2.1 km (1.3 m) below dam	56% mosquitofish
2.1 km below dam (in isolated pool)	38% mosquitofish
2.9 km (1.8 m) below dam	100% mosquitofish

10. Santa Cruz River (private) is stream habitat with strong and unpredictable flooding and drying events with concomitant fluctuations in fish populations. Topminnow continue to exist despite mosquitofish, and were measured near the gaging station NE of Lochiel over time as follows (Minckley et al. 1977, Meffe et al. 1983, Brooks 1986, this study):

Date	Status
historically	present and probably abundant
1963-1974	no records of topminnows
April 1976	mosquitofish = 99%
Sept. 1976	" =96%
March 1977	=96%
June 1981	" = 3%
1985	mosquitofish > topminnows (no exact counts)
July 1986	" =51%
August 1987	" =81%

11. Redrock Canyon (Coronado National Forest) is a gravel-bottomed stream which experiences strong flooding. The distribution of fish, including topminnow, appears to vary spatially and temporally within the system. Following reports of intrusion by exotic fish (Brooks 1986, Sheila Dean, pers. comm.), a survey in 1987 documented the following fish distributions:

Location	Mosquitofish Dominance
vicinity of falls below Redrock ranch (T22S R16E S2/11)	100%
vicinity of gate springs (T22S R17E S7)	14%
between red banks and gate springs (T22S R17E S7/17)	100%
below spring where road turns (T22S R17E S16 Ni)	62%
between spring where road turns and dry section (T22S R17E S21 NE¼)	73%
between dry section and Cott Tank (T22S R17E S21 SE¼)	100%

Introduced and dispersal populations

8. Salt Creek (San Carlos Apache Indian Reservation) supported a natural population of topminnow which was replace by mosquitofish between 1980 and 1984 (one red shiner was also collected). Following renovation, it now supports small numbers of topminnow introduced from Middle Springs (site #6). No exotic fish were observed at this site in either 1986 or 1987, although the same mechanism allowing invasion in 1979/1980 is presumably still available. Since it is possible reinvasion by exotics will occur again, this otherwise Category #1 site is instead Category #2.

12. Lower Mine Spring (Prescott National Forest) is a small spring obstructed by mine tailings to form a pool (10m²) densely vegetated with grass and Typha. Topminnow are abundant. Since the tailings will eventually wash down slope eliminating all topminnow habitat, this is a Category #2 site.

15. Thicket Spring (Tonto National Forest) is a small (10m²) stockpond with abundant topminnow and, in 1986, dense Typha. The fence excluding cattle from this site was gone in 1987, all Typha was consumed by cows, the pond was severely trampled, and topminnow had a noticeably high incidence of parasites (ID not yet determined) which I have not observed in other populations of Gila topminnow. Because topminnow will not persist when the present barrier forming the stockpond erodes, this is a Category #2 site.

16. Mud Spring Tank (Tonto National Forest) is a small (10m²) stockpond with half of its surface fenced from cattle. Topminnow are present but dominated by mosquitofish which accessed the site by unknown means. Mosquitofish represented 92% of fish present in 1986 and 97% of fish in 1987; thus this is a Category #4 site.

18. Mud Spring (Tonto National Forest) is a small ($5m^2$) pool of water. A substantial (-50%) portion of the habitat is within a cement watering trough which is the only place topminnow where found in 1987. The population is greatly reduced in 1987 compared to 1986 and is estimated to be less than 10 individuals. Water other than in the trough is very shallow (largely hoofprints), without substantial vegetation, and apparently not populated in 1987. Given the limited habitat and population size, this is a Category #3 site.

19. Dutchman's Grave Spring (Tonto National Forest) is remotely situated in the Mazatzal Wilderness Area and was visited by me only once, in September 1986. The habitat is a stream 2-3 m wide and .1-1.0 m deep with dense riparian overstory. Topminnow of various age classes were abundant at this visit, and I assume the populations is still doing well. Moreover, given the remoteness of the site and its well-watered length (.5-1.5 k), this is a Category #1 site.

20. Walnut Spring (Tonto National Forest) is a moderate (20m²) stocktank in a steep canyon with moderate riparian overstory. The actual tank is well shaded and has mud turtles (Kinosternon) as well as a large topminnow population. Because this habitat will be lost when the barrier forming the stockpond erodes, this is a Category #2 site.

21. Sycamore Spring (Tonto National Forest) is a small (5m²) habitat which results from the spill of a cement watering trough. The site is shallow (.1-.5 m) and moderately trampled by cattle, and was colonized by crayfish between 1986 and 1987. Topminnow have been consistently abundant in this limited habitat although water is transferred via pipes to fill the trough. This is a Category #2 site.

23. Yellowstone Tank (Coronado National Forest) is a medium ($20m^2$) stockpond which is lightly trampled by cattle and has scant vegetation around its border. Topminnow are abundant but the tank relies on a man-made barrier to create adequate habitat. This is a Category #2 site.

24. Indian Spring (Tonto National Forest) is remotely situated in a canyon feeding into Apache Lake from the north. Access to the site is only by boat, followed by hiking through either dense vegetation (in the canyon) or up steep hillsides (around the canyon). Indian Spring originates in a broad canyon 1 km from Apache Lake and drops rapidly into a narrow canyon. Topminnow were present but scarce immediately above the first drop off into the narrow section of canyon, becoming more abundant downstream in narrow plunge pool habitat. Starting 200-300 m from the lake, crayfish appeared and became progressively more abundant downstream. Other fish were not observed in the canyon though many Centrarchids were evident in the lake at the canyon's mouth. Given its remoteness, natural water supply, and abundant topminnow, this is a Category #1 site.

25. Campbell Flat Spring (Prescott National Forest) is a well-watered habitat but with very few topminnow. Despite thorough sampling of the spring and adjacent stream, only 6 individuals were observed in 1986, and only 3 were observed in 1987. Only large adult topminnow of both sexes were found in the springhead. No evidence of successful reproduction was found, and so this is a Category #3 site.

26. Bain Spring (Prescott National Forest) is a natural spring/stream with a native fish fauna of longfin dace and Gila mountain sucker. The site is currently fenced effectively from cattle and supports a thriving topminnow population in a well vegetated riparian corridor. This is a Category #1 site.

28. Peoples Canyon (Bureau of Land Management) is a deep canyon accessible only by foot. Although topminnow are persisting at this site, it is not within historic range, hence does not count toward recovery goals. Accordingly, I have not categorized this site.

31. Pasture Well (Prescott National Forest) is a small ($5m^2$) pond bisected by a cattle fence. It is connected via a plastic hose to an unnamed spring which was stocked with topminnows. Presumably topminnows entered this site via the hose although they may have been transported by humans or some other means. The unnamed spring lost its topminnow population in 1987 since I found dead and drying topminnow in the spring bottom in mid-July. Pasture Well still supports topminnow though the habitat is small and dependent on water transport via a plastic hose. This is a Category #3 site.

32. Horrell Springs (Tonto National Forest) is actually upper Champaign Creek near where Horrell Springs originates. The entire area is exceptionally well vegetated with huge walnuts, sycamores, cottonwoods, and lush understory. In 1987, topminnow were abundant from at least ½ mile above Horrell Springs (within the Superstition Wilderness Area) to the lower road crossing about 1.5-2.0 km below Reevis Mountain School. Other species of fish are not present although wildlife in general is abundant. This is a Category #1 site.

33. Government Springs (Prescott National Forest) is located in the median between north and south bound lanes of interstate 10. Topminnow were present but not abundant at this site in 1987. Except for accidental or intentional toxic dumping (which may be likely over many years) this population appeared well watered. Given its proximity to dense human activity, potential for chemical annihilation, and uncertain water source this is a Category #2 site.

36. Tres Alamos (Bureau of Land Management) is actually a large ($5m^2$) tinaja in a side canyon near Tres Alamos falls (about 100 m downstream). This site supports topminnow but is not within historic range, hence does not count toward recovery and is not categorized here.

38. Mesquite Flat Trough (Tonto National Forest) is a cement cattle trough on a dry desert hillside supplied with water by a pipe. Natural surface water is not evident in the area. Topminnow persist within the watering trough, but this is not a large population (estimated to be less than 100 individuals). Given the small population size, and since the site will not support fish after the water system built by man fails, this site is a Category #3 site.

40. Artesian Well #3 (Tonto National Forest) is a small ($10m^2$) pool in an otherwise flat dry area. Water is supplied by a pipe, and a large portion of the bottom of this pool is covered with an artificial barrier, much like an umbrella, presumably to thwart Typha which is dense elsewhere in the pool. Topminnow are abundant, but given the site's artificially maintained nature, this is a Category #2 site.

41. Corner Artesian (Tonto National Forest) is at the corner of a fence line in an otherwise flat dry area. Water flows a short distance before pooling behind a manmade barrier to form the bulk of the habitat. Topminnow are abundant, but given the site's dependence on an unnatural barrier which will eventually erode, this is a Category #2 site.

42. Kayler Spring (Tonto National Forest) is a natural spring flowing into Tonto Creek above Roosevelt Lake. Following report of possible mosquitofish at this site (Brooks 1986), mosquitofish were confirmed present in 1987. The pattern of occurrence of mosquitofish was similar to that described for other systems (Minckley et al. 1977, Meffe 1984):

Location	Status
Kayler Spring at confluence with Tonto Creek	46% mosquitofish
100-200 m upstream of confluence	100% topminnow

43. Reed Spring (Tonto National Forest) is a short (150-200 m) stretch of mostly shallow pools among rocks at the mouth of a narrow, rocky, steep canyon. Although topminnow are absent or not abundant from much of the reach, they are moderately abundant in several pools in the middle section of the habitat. The habitat is natural but may dry on occasion. Based primarily on the limited abundance of topminnow in this marginal system, this is a Category #2 site.

44. Yerba Mansa (Bureau of Land Management) is an impounded spring forming a rather oblong pool (15 m x 40 m) with dense Typha and submerged vegetation. Topminnow are abundant but this site is not within historic range, hence does not count toward recovery, and is not categorized here.

45. Mesquite Spring Tank (Tonto National Forest) is actually a tiny spring flowing from the base of the original stockpond which is now dry. Only 2 small (1 x 5 m) pools appear to support fish although additional water, especially downstream, was present during my two summer visits. The population is probably less than 200 fish. Given the site's limited habitat and small population, this is a Category #3 site.

46. Horse Creek (Tonto National Forest) is a small bedrock spring/stream about 1.0-2.0 km from the Verde River. The site has a well-developed riparian corridor and water with abundant topminnow for at least several hundred meters. This is a Category #1 site.

48. Hidden Water Spring (Tonto National Forest) is the oldest introduction site having been established in 1976 (Minckley and Brooks 1985). Hiking is required to visit this site which is well hidden among towering canyon walls. Moreover, the aquatic system here is extensive covering at least a kilometer of streambed with deep pools of abundant topminnow and longfin dace. This is clearly a Category #1 site.

49. Seven Springs (Tonto National Forest) is an extensive (1-2 km) system which at times supports thousands of topminnow. The riparian canopy is well developed, and although the area receives high recreational use, topminnow are persisting. At times topminnow are scarce and apparently there are refugia upstream from the main public access road. Such refugia might provide colonizers following population declines elsewhere in the system (Minckley et al. 1977). A dense population of crayfish was observed in 1987, while topminnow were scarce but present. Given its tendency for population fluctuation and the relatively high threat of introductions of mosquitofish by its many visitors, this is a Category #2 population.

67B. Castle Creek (State) is a single plunge pool with a dense topminnow population. The pool is about 1.5 m deep and 2 m x 5 m in area. This population presumably washed downstream from Bench Well, an unsuccessful site which is 5 km upstream. Given the limited habitat this is a Category #3 site.

68B. Unnamed Drainage #68 (Tonto National Forest) is a series of scoured and cut bedrock pools at the mouth of a narrows-type canyon. The population at this site presumably washed into the area from upstream where a successful introduction site existed for several years. Although the level of these pools fluctuates greatly (down about 1 m when I visited in August 1987 compared to 1986), topminnow were still dense in at least three pools. Based on its abundant topminnow, but recognizing the high probability that these bedrock pools do dry occasionally, this is a Category #2 site.

72. Cow Creek (private) has well-vegetated and well-watered areas with abundant topminnow, and some intermittent areas which at least occasionally support topminnow. Although populations at this site are potentially vulnerable to exotic fishes dispersing upstream into Cow Creek via Humbug Creek (#95), this is still a Category #1 site.

74. Tule Creek Unnamed Spring 1 East (private) is a tiny (.5 m^2) pool with dense topminnow but not a large population size due to its small volume. This site sits in an otherwise dry wash with little to suggest it will not dry when a strong drought occurs. This is a Category #3 site.

75. Tule Creek (Bureau of Land Management and private) is a mixed cienega/stream-bed habitat supporting a sizable topminnow population. As documented by Collins et al. (1981), this site is subject to occasional destructive flooding. In 1987, two plunge pools (1 m deep and about $2m^2$) with dense numbers of topminnow were found several km downstream from upper Tule Creek. This is a Category #1 site, though it might be considered #2 based on flooding (Collins et al. 1981).

76. Heron Spring (private) is a cienega/spring habitat isolated from other waters except perhaps during floods. This site was stocked with topminnow from Sharp Spring after careful sorting to exclude mosquitofish which infest Sharp Spring. Both sorting and introduction were successful as a pure topminnow population now exists in Heron Spring. This is a Category #1 site.

77. Cottonwood Artesian (Tonto National Forest) originates in a cement watering trough which spills to form a modest spring which flows 50 in to a pool densely overgrown by Typha. Topminnow are abundant throughout the system wherever sufficient water exists. There are no centers of density, however, because the pool (with Typha) is not deep enough nor clear enough of Typha to provide extensive habitat. The greatest numbers of fish are in the watering trough which is, of course, constructed and maintained by man. Because of this human dependency to maintain the suitability of the site for topminnow, this is a Category #2 site.

80. Boyce-Thompson Arboretum (state) is a large (1.5-2.0 hectare) pond formed by transporting water from Queen Creek into an artificial basin above the drainage. This site is now severely infested with fathead minnows (Pimephales promelas) which represented the majority of fish biomass in the system in summer 1987. Many thousands of topminnows, as well as desert pupfish (Cyprinodon macularius), also persist at the site. A long-standing problem of unauthorized introductions has forced renovation (successfully) of this site at least twice in the last ten years (USFWS 1983). This population was established in part to provide topminnow broodstock for introductions elsewhere, and is currently holding fish originally from Monkey Spring (site #2). Since further introductions of topminnow should not be with Monkey Spring stock, perhaps this site should be renovated again and restocked with an appropriate topminnow lineage. Greater effort at posting against fish introductions together with local education about endangered species goals, might prevent further problems with unauthorized introductions of exotics. Based on this recurring problem and the unnatural source of water, this is a Category #2 site.

81. Green Tanks (Bureau of Land Management) is actually two natural-looking deep pools situated in bedrock immediately below a (Green Tanks) stockpond. Topminnow are abundant in the lowermost pool and scarce in the upper pool. Al Bamman (Bureau of Land Management, pers. comm.) indicates only the lower pool was actually stocked. Leopard frogs are also abundant at this site but no other fish nor turtles were apparent. Based on the presumably natural origin of these fairly large pools (15 m x 40 in combined), and on the vigorous growth of these topminnow populations, this is a Category #1 site.

82. Mescal Warm Springs (Bureau of Land Management) is a remote site below San Carlos Reservoir and above the Gila River mainstream. Topminnow are abundant in this natural spring which was enlarged manually by volunteers from The Wildlife Society under supervision of Al Bamman. The entire site sits under a well-developed Riparian canopy, and is effectively fenced from cattle. This is a Category #1 site.

83. Big Springs (Bureau of Land Management) is a natural spring in otherwise dry desert which is made deeper and presumably suitable for topminnow by a cement dam 1.5 m high. Topminnow are abundant, but since the habitat will presumably not persist after the dam silts in or erodes, this is a Category #2 site.

84. Cold Spring (Bureau of Land Management) is actually two potholes ($5m^2$) dug in the hillside above and between upper and lower cold springs. Topminnow are present in moderate numbers in both potholes, but since these are clearly unnatural and not long-lasting habitats, this is (generously) a Category #2 site.

95. Humbug Creek (private) is a tributary of Cow Creek which had topminnow and no mosquitofish in its upper section (T7N **R1E** S6 SEI), but mosquitofish and no topminnow in its lower section (T7N **R1E** S7/8/17/18 intersection) in August 1987. Both species were observed in the lower section in March 1987. Exotics appear blocked from ascending upper Humbug Creek (hence Cow Creek) by a dam-like structure on upper Humbug Creek, although green sunfish were present a short distance above this dam. Below the dam mosquitofish, green sunfish, and red shiner are abundant. Given the presence of mosquitofish in this habitat, this is a Category #4 site.

98. Kino **Spring** (Fort Huachuca Military Reservation) is a small ($10m^2$) pond watered via piping from a source underground. The pond supports dense aquatic vegetation and a modest topminnow population. Desert pupfish are also present. Since the pond is manmade, and will not persist in the face of erosion, flooding, silting, and succession, this is a Category #2 site.

99. Buffalo Corral Pond Spring (Fort Huachuca Military Reservation) is a tiny spring which feeds the associated pond. It also has thick aquatic growth and a small population of topminnows (Dennis Coleman, pers. comm. -- I have not visited this site). Since the habitat and topminnow population at this site is small, this is a Category #3 site.

102. Red Creek (Tonto National Forest) is a narrow and shallow (3 in wide x .5 in deep) desert stream which dries almost completely during droughts (Glenn Jennings, pers. comm.). This site supports a well-developed riparian gallery, leopard frogs, and longfin dace. Topminnow were found only rarely in occasional backwaters and pools. This site was probably populated during flooding from Thicket Spring (site #15) which flows into a normally dry section of Red Creek drainage several kilometers upstream. Given the paucity of good topminnow habitat in Red Creek, the low number of topminnow observed there, and the likelihood of complete drying, this is a Category #3 site.

103. Rincon (Coronado National Forest) is a recently discovered population reported by Will Hayes, Arizona Game and Fish Department. Thousands of topminnow are existing in a watered section within Saguaro National Monument East. The site apparently dries occasionally and is a Category #3 site.